BROADBAND ROTATIONAL SPECTROSCOPY

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The past decade has seen several major technology advances in electronics operating at microwave frequencies making it possible to develop a new generation of spectrometers for molecular rotational spectroscopy. High-speed digital electronics, both arbitrary waveform generators and digitizers, continue on a Moore's Law-like development cycle that started around 1993 with device bandwidth doubling about every 36 months. These enabling technologies were the key to designing chirped-pulse Fourier transform microwave (CP-FTMW) spectrometers which offer significant sensitivity enhancements for broadband spectrum acquisition in molecular rotational spectroscopy. A special feature of the chirped-pulse spectrometer design is that it is easily implemented at low frequency (below 8 GHz) where Balle-Flygare type spectrometers with Fabry-Perot cavity designs become technologically challenging due to the mirror size requirements. The capabilities of CP-FTMW spectrometers for studies of molecular structure will be illustrated by the collaborative research effort we have been a part of to determine the structures of water clusters – a project which has identified clusters up to the pentadecamer. A second technology trend that impacts molecular rotational spectroscopy is the development of high power, solid state sources in the mm-wave/THz regions. Results from the field of mm-wave chirped-pulse Fourier transform spectroscopy will be described with an emphasis on new problems in chemical dynamics and analytical chemistry that these methods can tackle. The third (and potentially most important) technological trend is the reduction of microwave components to chip level using monolithic microwave integrated circuits (MMIC) – a technology driven by an enormous mass market in communications. Some recent advances in rotational spectrometer designs that incorporate low-cost components will be highlighted. The challenge to the high-resolution spectroscopy community – as posed by Frank De Lucia last year at the final meeting in Columbus – is what problems can we solve when real, fully capable spectrometers become essentially free to build?